THE INFLUENCE OF MATCHING TEACHING AND LEARNING STYLES ON THE ACHIEVEMENT IN SCIENCE OF GRADE SIX LEARNERS

by

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Declaration

"I declare that **THE INFLUENCE OF MATCHING TEACHING AND LEARNING STYLES ON THE ACHIEVEMENT IN SCIENCE OF GRADE SIX LEARNERS** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references."

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P. Dasari

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Summary

The aim of this investigation was to determine whether there is a significant difference in the academic achievement of sixth grade Science students when teaching styles are matched to their learning styles.

The research problem is encompassed in the following question:
"Is there a relationship between matching teaching and learning styles and the academic success in Science?"

A quantitative approach was undertaken, specifically, the pretest – posttest control group experimental design. The population comprised of sixth grade students selected according to a non-probability sampling method of convenience. The sample comprised of two class units randomly selected.

The dependent sample t-test inferential statistic was used to analyze the data collected. The results indicated a statistically significant difference between the pretest and posttest scores of the experimental group.

The conclusion reached is that matching teaching styles to learning styles improves the academic success of sixth grade learners in Science.

KEY TERMS:

Learning styles; teaching styles; experimental research design; pretest – posttest control group design, non-probability sample of convenience; visual learner, auditory learner; tactile/kinesthetic learner.

TABLE OF CONTENTS

CHAPTER ONE: ***Introductory orientation and statement of the problem***

TABLE OF CONTENTS

TABLE OF CONTENTS

CHAPTER THREE: ***Research design, methodology and data analysis***

TABLE OF CONTENTS

Chapter one: Introductory orientation and statement of the problem

1.1 Introduction

According to Winebrenner (1996:49), the most effective way to convince struggling students that they can learn is by creating awareness through teaching ***to*** their learning style strengths. This implies that there should be an intricate relationship between the teaching strategies of the teacher and the learning preferences of the students. Winebrenner (1996:49) further states that learners should be taught about their learning styles, so that they are empowered to act intelligently when learning seems difficult for them.

The purpose of the proposed study is therefore twofold. Firstly, it is intended to investigate the benefits of teaching to learning styles. Secondly, it is intended to evaluate the success of teaching in accordance with learning styles in an attempt to improve the academic performance of learners in a Middle School Science classroom.

1.2. Problem Analysis

1.2.1 Awareness of the problem

It has been the researcher's experience as a teacher that many learners fail to achieve an acceptable level of success in Mathematics and Science disciplines. Students generally complain that these subjects are too difficult for them to cope with.
Is it possible that some students are failing to be successful at school because teaching methods do not cater for their learning styles?
Much of my reading on this topic suggest that the boredom, lack of success and frustration students experience at school could be due to incongruence between the teaching strategy of the teacher and their preferred learning styles.
This inherent problem gave rise to the idea for this research topic. It was thus born out of a desire to provide teachers with an alternative approach to improve the learning productivity of their students.

1.2.2 Motivation and importance of the study

The importance of this study is that it creates an awareness of an alternative approach to successful learning.

A learning styles approach stimulates learners at a meta-cognitive level to consider conditions conducive to their learning so that they may derive the maximum benefit from it.

Students will learn better if they understand the conditions that promote their learning. They will also become better learners if they can broaden their preferences (Connor, 1997:3).

Kolb (quoted in The Curriculum Journal, 1995:325), suggests that the incongruence of the learning environment provided by the teacher, and the learning styles favoured by the individual students can lead to anomie and alienation in the classroom. This implies that a failure to address the learning styles of students can lead to classroom disruptions that could affect learning. It is hoped that this study will help educate teachers about the importance of expanding teaching strategies to accommodate various learning preferences so that all learners can be included in the learning process.

1.3. Preliminary Literature Study

The study focuses on benefits of a learning style approach in promoting academic achievement in Science. Hence, it is essential to define and describe basic components of a learning style.

1.3.1 Learning styles

Drs. Rita and Kenneth Dunn (quoted in Rief & Heimburge, 1996: 5), describe a number of elements that make up a person's learning style. These include environmental elements such as sound, light and temperature; sociological elements such as being peer orientated, pair orientated, team orientated, self orientated and authority orientated; emotional elements which include motivation, persistence, responsibility and structure; and finally physical elements such as perceptual/modality strengths, time of day, eating and drinking needs and need for mobility.

In keeping with the elements described above, learners may be classified as auditory learners, visual learners, tactile-kinaesthetic learners and analytical or global learners.

1.3.2 Learning style models

There are also various learning style models which attempt to identify the learning styles of people through the use of learning style instruments. Felder (1996) outlines four such models in his article 'Matters of Style', namely, the Myers- Briggs Type indicator (MBTI); the Kolb learning style model; the Hermann Brain Dominance Instrument (HBDI) and the Felder-Silverman Learning Style Model.

The Myers- Briggs Type indicator (MBTI) classifies learners according to preferences on scales derived from Carl Jung's theory of psychological types. According to their preferences, learners may be extroverts or introverts; sensors or intuitors; thinkers or feelers; judgers or perceivers. These types of preferences can then be combined in different ways to form at least sixteen different learning style types.

The Kolb learning style model classifies learners according to how they take information in and how they internalize this information. This model classifies four types of learners: the concrete, reflective learner; the abstract, reflective learner; the abstract, active learner; and the concrete, active learner. The terms 'concrete' and 'abstract' refer to how the learner takes in information, while the terms 'active' and 'reflective' refer to how they internalize the information taken in.

The Herman Brain Dominance Instrument (HBDI), groups learners according to their preference for thinking in four modes based on the task specializing functioning of the brain. Thus, a learner can be: left-brain, cerebral (Logical, analytical, quantitative, factual, and critical); left brain, limbic(Sequential, organized, planned, detailed, structured); right brain, limbic(Emotional, interpersonal, sensory, kinaesthetic, symbolic) and right brain, cerebral(Visual, holistic, innovative).

The Felder- Silverman Learning Styles Model consists of five dimensions: sensing or intuitive learners; visual or verbal learners; inductive or deductive learners; active or reflective learners; and sequential or global learners.

The details outlining each classification will be elaborated upon in chapter two of the dissertation. One of these instruments was used in the primary data collection phase to determine the preferred learning style of the learners in this study.

1.3.3 Teaching Styles

As with learning styles, there are also numerous classifications for teaching styles. Grasha (1996) describes five teaching styles in his book 'Teaching with Style'. These are: the expert; the formal authority; the personal model; the facilitator; and the delegator. Each preference has merits and demerits, the details of which will be elaborated upon later in this dissertation.

Benzie (1998) classifies teaching styles as assertive, suggestive, collaborative, and facilitative. These styles range from being teacher centred to child centred.

The usefulness of an investigative study such as this is enhanced by considering previous research findings on similar applications of matching teaching styles to learning styles.

In a study by Zhenhui (2001), the impact of culture on the learning styles of learners and how mismatches between this and the dominant teaching styles of teachers foreign to the culture can cause learning problems, is investigated. The conclusion reached is that the gap between teacher intention and learner interpretation should be reduced if desired outcomes want to be achieved.

A similar conclusion is reached by Felder and Henriques (1995) in a study on teaching and learning styles in foreign and second language education.

In a computer based learning activity, Ford and Chen (2001:1) agree that learning performance is improved when instructional strategies match learning or cognitive styles of learners.

In a slightly different study by Garland and Martin (2003) , the relationship between learning style as measured by the Kolb Learning Style Inventory, and the level of engagement as measured by the utilization of class content areas in internet courses was investigated. Results show that the relationship between learning styles and level of engagement was in fact divided by gender. This provides another angle from which a study on matching teaching styles to learning styles can be approached.

The conclusions of each of the studies described provided the background for the formulation of the research question and related objectives of this study.

A more detailed exposition of the literature will follow in chapter two.

1.4. Research problem and aims of the research

1.4.1 Statement of the problem

"Is there a relationship between matching teaching and learning styles and the academic success in Science?"

1.4.2 Aims of the research

1.4.2.1 The aims of the theoretical investigation

In contemplating the research problem for this study, consideration was given to the following points penned by Connor (1997:3):

- Will students learn better when using preferences in which they are successful?
- Will students be better learners if they can expand their preferences?
- Will students be more successful if teaching accommodates their preferences?

The research problem thus attempts to answer some of the questions stated. The aim of the theoretical investigation was to review the available literature regarding learning styles. The focus was also to examine other research findings related to matching learning and teaching styles.

1.4.2.2 The aims of the empirical investigation

The primary objective of the empirical study was to determine if there is a significant difference in the academic achievement of grade six Science students when teaching strategy is matched to their learning styles.

As a secondary objective, it aimed at educating learners in the process, how to identify conditions suitable to their optimal learning and take advantage of this. This was done by exposing learners to available literature on the learning styles approach.

As outlined before, research articles by Felder (1996), Zhenhui (2001), Garland and Martin (2003) and others expound the benefits of matching teaching styles to learning styles. Another purpose of this study was therefore, to add to the existing body of knowledge pertaining to this subject.

1.5. Research Design: Experimental design

For the purpose of this study, a quantitative research design appears appropriate. Specifically, the experimental design of a pre-test- post-test control group has been selected.

In such a design, there are two groups, an experimental group, and a control group. Both groups are pre-tested on the particular variable inherent in the study. The experimental group then receives the treatment, while the control group receives no treatment.

This design was selected in order to control threats to the internal validity of the study. McMillan and Schumacher (2001:337) describe four threats that are controlled by this method. They are threats associated to history, selection and maturation, statistical regression and pretesting.

History refers to extraneous incidents or events that may affect the results that occur in the research (McMillan & Schumacher, 2001:186). As far as history is concerned, events external to the study will affect the entire group equally.

Although the population was not selected in a strictly random way, the groupings of learners are such that that there is an equitable distribution of learners at different levels of intelligence, with different strengths, in each class grouping. This is in order to control the threat presented by selection.

Diffusion of treatment could be a possible threat in this study because all subjects were from the same grade in the same school. In order to control this, the treatment group was administered by one instructor and the control group was administered by another.

1.6. Research Methodology

1.6.1 The sample

The sampling method of choice for the study was a non-probability sampling of convenience. A convenience sample refers to a group of subjects selected on the basis of being accessible or expedient (McMillan & Schumacher, 2001:175). The researcher chose this method of sampling because it provided the only possibility for carrying out the research.

The population from which the sample was selected for this study is the grade six Science students at the school the researcher is currently teaching. The total population comprises of eighty-seven students grouped into five class units. The average class size is approximately seventeen.
Although not ideal, two class units, each comprising sixteen students, were randomly selected as the experimental group and the control group respectively. This was in order to assume and maintain statistical equivalence.

It is important to note here that the class units selected was representative of the entire sixth grade population in terms of age, cultural background, educational experiences, and socio- economic status.
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1.6.2 The course of the research

In total, administering the treatment aspect of the research took approximately eight weeks.
At the beginning of the empirical investigation, the experimental group was administered with a learning style inventory in order to determine learning preferences within the class unit.

The teacher then planned two Science units in cognizance of the learning preferences identified in the experimental group. During instruction (treatment), the instructor varied teaching styles in accordance with the learning preferences inherent in the class.
The control group was taught in ignorance of their learning preferences or styles.

1.6.3 The instrument/test

The school from which the sample population was chosen works on a trimester system. At the commencement of the research, the students were beginning the third trimester for the year.
Therefore, the second trimester Science grades were used as a pre-test score.
At the end of the first unit of Science, a post-test was given and the means of the pre-test scores and the post-test scores of the experimental group were compared for any

significant difference. The post-test took the form of a Science unit of enquiry written test.

The pre-test and post-test results of the control group were also compared. Thus, the averages or means of the test results constituted the data collected.

The treatment was repeated for a second Science unit in order to determine consistency and relevance of results.

1.6.4 Data analysis

The dependent samples t-test was used to analyze the data and indicate any statistical significance. This test is appropriate because the same group (the experimental group) was tested twice, in a pre-test and a post-test situation. The dependent samples t-test was also used to determine whether there was any significant difference in the Science test scores of the control group.

The results of both groups were then compared so as to draw conclusions on the influence of matching teaching styles to learning styles, and its impact on the Science achievement of sixth grade learners.

Details surrounding the collection and analysis of the data are described in chapter three.

1.7. Definition of core concepts

1.7.1 Learning styles

A learning style is the more or less consistent way in which a person perceives, conceptualizes, organizes, and recalls information (Verster, 2005:1). Dybvig (2004:2) defines a learning style as the way a person processes, internalises, and studies new and challenging material. Thus, it affects the way we think, act, and approach our learning. From these definitions, it is clear that individuals have their own unique way in which they approach learning or the mastery of material. Rief and Heimburge (1996:2) believe that recognizing learning styles should be the first step teachers take in order to be most effective in working with students of diversity.

1.7.2 Teaching styles

Teaching styles refer to the behaviours that teachers' exhibit in their interactions with learners (Heredia: 1999). They are distinct from methods of instructions.
A definition proposed by Hoyt & Lee (in the IDEA Research report #4 of 2002), is that a teaching style refers to the way various teaching approaches are combined. Each "style" resembles a "recipe" in which the ingredients are teaching approaches combined in ways designed to produce an optimal outcome.

1.8. Outline of chapters

- **Chapter 1**: ***Introductory orientation and statement of the problem***

- **Chapter 2**: ***Learning style and teaching style models.***

  This summarizes the research reviewed on the topic and conclusions drawn from it. This chapter is divided into three sections. Section 1 provides details on different theories of learning styles. Section 2 elaborates on the teaching styles briefly mentioned on the preliminary literature study. Section 3 outlines research findings representing opposing viewpoints on the benefits of a learning style driven education programme.

- **Chapter 3: *Research design, methodology and data analysis***

  The design and methodology followed for the research is described in this chapter. This chapter also includes the analysed data.
  Results are presented in the form of tables, calculations, and graphs, followed by a discussion of their significance, meanings, and implications.

- **Chapter 4**: ***Summary, conclusions, recommendations and implications***

  The findings of the research are outlined, including limitations and implications
  Recommendations for future applications of the research are discussed
  Appendices are also included in this chapter.

Chapter 2 – *Learning style and teaching style models*

2.1 Introduction

This chapter summarises the literature reviewed for the research study. The review comprises of three sub-sections. The first section begins by classifying learning style models before providing a brief synopsis of five popular models. The section concludes with an attempt to highlight the common principles inherent in all the learning style models reviewed for this study. The second section outlines various thoughts on teaching styles. The third section presents available research findings in favour of matching teaching styles to learning styles, as well as findings of critics who are not in favour of matching teaching styles to learning styles. The underlying conclusion is that the issue of matching teaching styles to learning preferences of students is controversial, and an area of education that requires much more research.

2.2.1 Defining and classifying learning style models

The impact of learning styles on student achievement appears to be a much researched and debatable topic.The underlying idea of a learning styles approach is that a person learns more effectively when information is presented in a manner that matches his preferred method of acquiring and processing information (Montgomery, 1995:1).

There are several definitions of learning styles, but each encompasses basic tenets as presented in the following definition:
"A learning style is the consistent pattern of behaviour and performance by which an individual approaches educational experiences. It is therefore the composite of characteristic cognitive, affective, and physiological behaviours that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment" (Ellis, 2001:149).

Another definition presented by Riding and Rayner (quoted in Hillberg & Tharp, 2002:1), is that a learning style is an individual's repertoire of learning strategies (ways in which learning tasks are habitually responded to) combined with cognitive style, which is the way in which the information is organised and eventually represented.

An analysis of available literature indicates that there are several ways in which learning style models can be classified.
One such classification by Curry (quoted in O'Connor, 1997: 3), categorizes human learning differences as layers of an onion. This onion model has four layers. The outermost layer is comprised of the observable traits, like instructional and environmental preferences. The Dunn and Dunn model of learning styles (Winebrenner, 1996:48), for example, highlights different dimensions within this layer. Basically, this layer deals with perceptual modalities.

The second layer, social interaction models, look at differences related to gender, age or maturation levels.

The third layer encompasses those models described as information processing models. These models attempt to understand how information is obtained, sorted, stored and utilized. Popular models within this category include Kolb's experiential learning approach and Howard Gardner's theory of Multiple Intelligence.

The innermost layer of the onion contains those models described as personality models. The premise of these models is that our deepest personality traits shape our perception and orientation about how we interact in our world. The Myers-Brigg type indicator is a popular model within this category.

Ellis (2001:150) provides another interpretation of how learning styles models may be characterised. Table 2.1 that follows is an adaptation of his categorisation.

Table 2.1: Categorising learning style models

Category	Characteristics	Researchers
Cognition – perceiving, finding out, obtaining information	Sensing/intuition	Jung, Myers-Brigg, Mok, Keirsey and Bates
	Field dependant/field independent, abstract/concrete	Witkin, Gregorc, Kolb and McCarthy
	Visual, Auditory, kinaesthetic, tactile	Barbe and Swassing; Dunn and Dunn
Conceptualization – thinking, forming ideas, processing, memory.	Extrovert/introvert	Jung, Myers-Brigg, Keirsey and Bates
	Reflective observation/active experimentation	Kolb and McCarthy
	Random/sequential	Gregorc
Affect – feelings, emotional response, motivation, values, judgement	Feeler/thinker	Jung, Myers-Brigg, Mok, Keirsey and Bates
	Effect of temperature, light, food, time of day, sound, design.	Dunn and Dunn

Within the scope of this review, learning style models designed by Dunn and Dunn, Kolb, Myers-Brigg and Herman will be described, in an attempt to provide an overview of learning style models exemplifying different categories of classification. In addition, a brief overview of the model developed by Felder-Silverman will be discussed.

2.2.2 Learning style models

2.2.2.1 Dunn and Dunn Learning Style Model

Drs. Marie Carbo, Rita Dunn and Kenneth Dunn describe three styles of learning:

- Auditory – people who learn by listening.
- Visual – learn by seeing, pictorial representations.
- Tactile/ Kinaesthetic – learn by touching and moving (Winebrenner, 1996: 43).

This is commonly referred to as VAK (visual, auditory, kinaesthetic). People use all three to receive information, but one or more of these styles can be dominant. Clark (2000:2) states that learners may prefer one style for a particular task and another for a different task.

This model falls within the perceptual modality as it is primarily concerned about how we take in information. It can be said to be based on biologically based reactions to the physical environment (Clark, 2000:8).

According to Winebrenner (1996: 43), auditory learners are logical, analytical and sequential thinkers. This type of learner may be most successful in traditional classrooms since their style is accommodated in most school tasks. Visual and tactile-kinaesthetic learners, being more global thinkers may run into problems as they are not good with logical, analytical and sequential tasks unless they can see the 'big picture'.

This clearly has important implications for teachers.

Restak and Thies (quoted in Dunn, 1996:1), believe that more than three fifths of a persons learning style is biologically imposed. The Dunn model extends this to include five factors or dimensions that influence a learning style (O'Connor, 1997:3). They are: environmental preferences(such as class design, sound lighting, temperature); emotional preferences (such as motivation, persistence, responsibility); sociological preferences (learning relations – isolated, team, peer, group); psychological preferences related to perception, time, mobility; and physiological processes.

There are four factors that significantly differ between groups and among individuals according to this model (Dybvig, 2004:3). The first factor is age.
According to Dunn (1996:2), learning preferences may change over time as they are developmental and alter with maturity. This could be due to motivation levels, responsibility, and the fact that for many people, visual and auditory perceptual elements strengthen with age (Dybvig, 2004:3).

The second factor involves global versus analytical thinking styles. The third factor is gender, implying that males and females learn differently to each other. The perceptual strengths of males tend to be visual, tactile and kinaesthetic; while that of females tend to be more auditory. The fourth factor indicates that high and low academic achievers tend to learn in statistically different ways.
In the book 'How to implement and supervise a learning style program', Rita Dunn mentions several research studies that support the hypothesis that academic achievement can be improved by teaching to learning styles, the most notable being an increase in Standardised Achievement Test scores (SAT's). However, there are several dissenting voices who question the quality and validity of research undertakings within this learning style model (Ellis, 2001:156).

2.2.2.2 Kolb's Experiential Learning Style Model

Kolb's learning style model, published in 1984, builds on Carl Jung's claim that learning styles result from peoples' preferred ways of adapting in the world (Chapman, 1995:5).
His model is made up of four distinct learning styles which are based on a four stage learning cycle. The four elements making up the learning cycle are concrete experience, observation and reflection, formation of abstract concepts, and testing in new situations (Smith, 2005:2). The logic behind this cycle is clear. Immediate concrete experiences provide the learner with a starting point for observations and reflections. As these are understood and assimilated, it can be applied to abstract concepts which can then be tested in new situations.

This cycle of the learning event provides the backdrop for the four learning styles proposed in this model (Felder, 1996: 5). These are:

a) Type 1 – the concrete, reflective learner

A learner operating within this style is concerned with why and how course material relates to their experiences. This learning style is also referred to in literature as diverging. People with this type of learning style can view a situation from many different perspectives (Chapman, 1995: 4). They love to work in groups, can listen with an open mind, and tend to perform better in situations that require generation of ideas.

b) Type2 – the abstract, reflective learner

Learners for whom this is a predominant style are concerned with the characteristic question of 'what?' They cope well with content presented in a logical, organised fashion. This style is also referred to as assimilating. In formal learning situations, people with this style prefer readings, lectures, exploring analytical models, and having time to think through a problem (Chapman, 1995: 5).

c) Type 3 – the abstract, active learner

This type of learner responds well to opportunities to be actively involved in a task and to learn by trial and error, provided it is in a safe environment. Another way of referring to this style is converging. People with this preference are attracted to technical tasks. They like to experiment with new ideas, to simulate and work with practical applications (Chapman, 1995: 2).

d) Type 4 – concrete, active learner

A learner with this predominant style likes to work on 'what if?' situations and enjoy the application of coursework to solve real problems. This style is also describes as accommodating (Chapman, 1995: 2). This learning style is useful in situations requiring action and initiative.

Examination of the four learning styles shows that it is really a combination of a two-by-two matrix of the four stages of the experiential learning cycle.

This model further proposes that a learning style is a product of two choice decisions; how we approach a task (do we prefer to ***watch*** or ***do***); and our emotional response to an experience (do we prefer to ***think*** or **feel**). Kolb places these constructs as opposing modes along an axis (Chapman, 1995: 3). The outcome of these two decisions or choices produces our preferred learning style.

Like Dunn and Dunn, Kolb's model also appears to suggest that our preferred styles improves or changes as we mature.
Kolb (quoted in Chapman, 1995: 2), identifies three developmental stages that are a factor in influencing a person's learning style, namely:

- Acquisition – from birth to adolescence.
- Specialisation – schooling, early work and personal experiences of early adulthood which leads to the development of a specialised style that is affected by a person's social, educational and organisational socialisation.
- Integration – from mid-career to later life.

As intriquing as this model may sound, it does not escape criticism. Greenaway (2006) identifies a number of weaknesses inherent in this model. A key issue concerns both reliability and validity of the learning style instrument. The idea of a learning cycle is also considered by some to be flawed, especially in the sense that it is closed, providing no avenue for a unique method of processing information.
Greenaway (2006) also contends that there is little evidence that matching improves academic performance in further education. The aspect of research findings in support of a learning styles approach will receive attention in section 2.4 of this review.

2.2.2.3 Myers- Brigg Type Indicator (MBTI)

As previously stated, this model classifies learning styles in accordance to personality types. It classifies people in accordance with preferences derived from psychologist Carl Jung's theory of psychological types (Felder, 1996:1).
There are four dimensions underlying the MBTI which through a number of combinations result in sixteen learning styles.
Scores obtained from answering the 126 items on the Myers-Brigg instrument indicates a person's preference on each of four dichotomous dimensions (Clark, 2000:4). These dimensions are:

a) Extroversion (E) versus Introversion (I)

Essentially, it indicates where a person derives his energy from. According to theory, introverts derive their energy from their inner world of ideas, concepts and abstractions. They are reflective thinkers and would rather think than talk.

b) Sensing (S) versus Intuition (S)

Brightman (2006:2) states that sensing people are detail orientated, want facts, and trust them. They rely on their senses to perceive their world. Therefore, they prefer organised, linear and structured lectures (Clark, 2000:5).

Intuitors, on the other hand, trust to some extent their hunches (or 'sixth sense'). They look for patterns and relationships in information.

c) Thinking (T) versus Feeling (F)

Felder (1996:1) describes thinkers as sceptics, who make decisions based on logic and rules. Thus, they rarely allow emotions to cloud their decisions. Conversely, feelers tend to make decisions on personal and humanistic considerations. They value empathy and harmony.

d) Judgers (J) versus Perceivers (P)

Judging people are decisive, focus on completing a task, is only concerned with what is essential, and can be hasty in taking action. (Brightman, 2006:5)

On the opposite scale, perceivers are by nature curious, adaptable and spontaneous. A disadvantage is that they may start a task but often find it difficult to complete it.

As mentioned previously, the four dimensions of this model can be combined to create up to sixteen learning style types, for example, a learner can be an extrovert, sensor, thinker and perceiver.

The MBTI is essentially a personality model but as such, has links to other models, especially Kolb's in that they both draw on work done by Jung. Also, our personalities play a big role in determining our learning styles.
Chapman (1995:5) identifies relationships between this model and that of Kolb. The MBTI dimension of 'feeling/thinking appear to be correlated with the concrete experience/abstract conceptualisation dimension in Kolb's model. Also, Kolb's active/reflective aspect correlates with the extraversion/introversion dimension as measured in MBTI.

2.2.2.4 Felder-Silverman Learning Style Model

This model was originally designed by Dr. Felder in collaboration with Dr. Silverman. It was initially used by college instructors and students in engineering and the sciences, but has subsequently been applied in many other disciplines (Felder, 2006:1).
Felder and Silverman (1988: 675) state that a students learning style may be determined to a large degree by asking the following questions:

- What type of information does a student preferentially perceive?
- Through which sensory channel is external information most effectively perceived?
- With which organisation of information is a student most comfortable?
- How does the student prefer to process information?
- How does the student progress towards understanding?

In answer to these questions, Felder (1996:20) classifies students as:

a) Sensing or intuitive

Sensing students are practical, orientated towards facts and procedures whereas intuitive students are innovative and oriented towards theories and meanings.

b) Visual or verbal

Visual learners prefer pictures, diagrams, graphs as models for material presentation. Verbal learners are comfortable with written and spoken explanations.

c) Inductive or deductive

This refers to their manner of reasoning. Inductive learners proceed from specific to general and deductive learners prefer presentations that proceed from general to specific.

d) Active or reflective

Active learners work thing out through trial and error, and by working with others. Reflective learners prefer to work alone and think things through.

e) Sequential or global

Sequential learners typically learn in small increments in an orderly manner. Global learners are capable of making huge leaps in their understanding as they see the bigger picture because they can think holistically.

As is apparent, this model shares many concepts in common with other models. One classification correlates to the VAK model, another to Kolb's experiential model, while still another tends to draw on personality model as inherent in the MBTI. Sequential and global differentiation of thinking correlates with the learning style inventory of the Dunn and Dunn model (Winebrenner, 1996:44).

2.2.2.5 Herman's Brain Dominance Model

This model was originally based on brain research, but has evolved to incorporate aspects of growth and development, especially creativity (Coffield, et al, 2004:34). It classifies learners according to their preferences for thinking in four different modes or quadrants that are based on the physical brain structure (Felder: 1996: 20).

These modes are:

- Quadrant A (left-brained, cerebral) – people within this mode are essentially logical, analytical, quantitative and critical thinkers.

- Quadrant B (left-brained, limbic) – people within this mode are sequential and organised. They prefer detail and structure.
- Quadrant C (right-brain, limbic) – people are more kinaesthetic, and emotional; emphasis on interpersonal relations; and are symbolic thinkers.
- Quadrant D (right-brained, cerebral) – people within this mode are visual, holistic and innovative thinkers.

Thus, simply stated, people may be one of four types; theorists; organisers; innovators; or humanitarians (Becta, 2005:8).

Although this model has been used to a large extent in business, it has as well utilised in education and training circles (Coffield, et al, 2004:34).

2.2.3 Tying the learning style models together

Through researching this aspect of the literature review, it has become evident that each model attempts to provide a way in which learning can be enhanced through examination of the various factors that influence learning. A common message found in all of the learning style models discussed is that:

- Some people have a predominant learning style but this does not mean that they cannot function within other styles. However, they do tend to learn more effectively if learning is orientated in accordance to their preference.
- As people grow older and successfully overcome successive developmental milestones, their learning preferences may change.
- Learning styles as a model is but a guideline and not a strict set of rules.

2.3 Teaching styles

2.3.1 Defining teaching styles

What is a style? The American Heritage Dictionary (2000) defines style as a combination of distinctive features of literary or artistic expression, execution, or performance characterising a particular person, group, school, or era. In relation to education, a teaching style may be described as a pervasive quality that plays an important role in several aspects of our teaching (Grasha, 1996:1). This implies that it is not simply an accumulation of techniques or interesting mannerisms, but also has

inherent in it the teachers personality and how this influences the way he/she selects instructional processes.

Brown (2003:1) states that teaching behaviours reflect the beliefs and values that a teacher holds about the learners' role in the exchange that occurs in the classroom. Brown further makes the point that research seems to support the idea that most teachers teach the way that they have been taught, for example, teachers who have experienced learning in an environment that was centred on the instructor and relied heavily on lectures, would understandably initially repeat that which worked for them in their own teaching style.

Can a teacher's approach to teaching then be modified? Heimlich and Norland (quoted in Brown, 2003:3), believe that there is an important pre-condition before teachers can attempt to modify their style.

"How educators select their teaching strategies and implement techniques is a function of their beliefs and values regarding the methods and can be modified to fit within the unique belief system of the educator. The manner in which any method, whether lecture or game, discovery based learning or discussion is used within a learning event is the choice of the educator and should be a reflection of his or her philosophy" (Brown, 2003:3).

This implies that before teachers can attempt to explore different teaching styles in an attempt to be more flexible, they must be receptive to the idea of change, and this should start with their beliefs about the students' role in the learning environment.

2.3.2 Examples of teaching styles

2.3.2.1) Felder – Silverman's interpretation of teaching styles

Just as there are five questions that can help determine a learning style, Felder-Silverman believes that teaching styles may also be defined in answer to five essential questions (Felder, 1988:675). These questions are:

- What type of information is emphasised by the instructor?
- What mode of presentation is stressed?
- How is the presentation organised?

- What mode of student participation is facilitated by the presentation?
- What type of perspective is provided on the information presented?

Based on the answers to these questions, teachers may emphasise concrete, factual information or abstract, conceptual and theoretical information.
Presentations may either stress visual modalities through pictures, diagrams, demonstration; or it may be verbal through lectures, reading and discussion.
With regard to organisation of lessons, this could be inductive, where observations lead to generalised principles; or deductive, where the generalised rule is mentioned and this leads to observed examples.
Teachers could either prefer student participation that is active through discussions and activities; or passive through students simply watching and listening.
Finally, teachers may prefer a sequential mode of presenting the material in a step by step manner; or they could prefer to present a global picture first and then proceed to break it down.

Does this mean that teachers are restricted to operating at either end of a spectrum when it comes to addressing the needs of the learners? Most definitely not.
Felder (1988:680) outlines several techniques that teachers could employ in addressing all learners in a classroom. These are summarised below:

- Motivate learning by relating it as much as possible to what was done previously and what will be coming.
- Provide a balance of concrete information and abstract concepts.
- Balance material that emphasises practical problem solving methods with material that emphasises fundamental understanding.
- Use pictures, schematics, graphs, and simple sketches liberally before, during and after verbal presentations.
- Do not fill every minute of the class period. Provide time for learners to reflect on what they have learnt.
- Ensure that there are ample opportunities for learners to do something active besides note-taking.
- Assign some drill exercises to provide practice in some basic methods being taught, but these should not be overdone.
- Applaud creative solutions, even incorrect ones.

- Talk to learners about learning styles so that they may be better informed of some of the factors that influence their learning.

2.3.2.2) D.D. Pratt's ideas on teaching styles

Pratt (quoted in Brown, 2003:3), presents five perspectives on teaching. These perspectives range from a teacher- centred focus to a learner- centred focus. Thus, teachers may employ techniques of:

Transmission – the teacher focuses on content and determines what and how students should learn.

Developmental – prior knowledge of the student is valued and the teacher's aim is to develop increasingly complex problem solving and reasoning skills in the learner.

Apprenticeship – authentic tasks in real work settings are presented.

Nurturing – the teacher focuses on the interpersonal elements of student learning. This includes listening to and getting to know the learner and responding to his emotional and intellectual needs.

Social reform – within this perspective, the teacher relates ideas explicitly to the lives of students.

The key factor for an effective teacher in considering these perspectives is to use a variety of styles in an integrated manner so that all learners' preferences are catered for.

2.3.2.3) Dan Benzie on teaching styles

The teaching styles proposed by Dr. Dan Benzie describe styles utilised by professors in tutoring medical students. However, they can easily be used to describe teaching styles within any context.

He describes four basic styles that operate on a continuum, where the characteristics of each style range from being teacher -centred on the left to student- centred on the right (Benzie, 1998: 1).

Teacher's experience **Learner's experience**

←----------→

Assertive **Suggestive** **Collaborative** **Facilitative**

In the assertive approach, the teacher provides information, direction and asks all the questions. Thus, it is driven by a lecture mode with the teacher being active and the students being passive. It is therefore on the far left of the teaching styles spectrum proposed by Benzie.
Moving away from this approach is the suggestive approach. Within the medical profession, this would imply that the teacher provides alternative perspectives on treatment or diagnosis in an attempt to allow the students to reflect, but with some direction. This could easily be applied to any teacher who may suggest alternative problem solving approaches to students.

In the collaborative teaching approach, student ideas are solicited through asking open, exploratory questions. There is a greater emphasis on student involvement.
In the Facilitative approach, the teacher asks open, reflective questions. The students are in control of much of the learning process with the teacher playing a facilitative or guiding role.

2.3.2.4) Anthony Grasha's impression of teaching styles

Grasha (1994: 1) defines a teaching style as a particular pattern of needs, beliefs and behaviours that faculty display in a classroom. His research, primarily with engineering college students, show that there are several patterns that describe the stylistic qualities of teachers. They include the teacher as:

- ***Expert*** – the transmitter of information.

Within this style, the teacher possesses the knowledge and expertise that the students require (Grasha, 1996:154). The advantage of this model is inherent in the fact that the teacher is well qualified in terms of a knowledge base. The disadvantage is that it may be intimidating to the student who cannot keep up with the train of thought of the teacher.

- ***Formal authority*** – sets the standard and defines acceptable ways of doing things.

A teacher operating within this framework has a certain status among the students as an expert and as one who sets expectations and rules of conduct (Grasha, 1996:154).

They provide students with structure that is necessary for them to learn. While this model may focus on clear expectations, it can become too rigid in terms of managing students and their concerns.

- ***Personal model*** - teaches by illustration and direct example.

Since the teacher is seen as the example, he becomes the prototype for how to think and behave (Grasha, 1996:154). He encourages students to observe and emulate his approach. An obvious advantage is that it emphasises observation and following a role model. On the other hand, it could create problems if the teacher believes his way to be the only way in that students may start to feel inadequate if they do not match up to the teacher's expectations or standards.

- ***Facilitator*** – guides and directs by asking questions, exploring options and suggesting alternatives.

The overall goal of this style is to develop in the students the capacity for independent action, initiative and responsibility (Grasha, 1996:154). The benefit of this approach is that it focuses on student needs and goals, and allows for creative thinking. It is, however, time consuming.

- ***Delegator*** – develop students' ability to function autonomously.

Within this perspective, the student works independently or in autonomous teams with the teacher available as a resource person only (Grasha, 1996:154). An obvious advantage is that it helps students to see themselves as independent and in charge of their learning. However, it will not work if the teacher misreads the student's readiness to work independently and in such a situation, it will only create anxiety.

Teachers are not simply placed into one of these five categories; rather they possess each of these styles in varying degrees. Grasha (1994:2) compares each style to a colour on an artist's palette.

Within his research program, he showed that the styles previously identified form four clusters of teaching styles and that 92% of classrooms examined for the study reflect one of the four clusters.

The four clusters include:

Cluster 1 – Expert/ Formal authority

Cluster 2 – Personal model/Expert/ Formal authority

Cluster 3 – Facilitator/Personal model/Expert

Cluster 4 – Delegator/ Facilitator/ Expert

In considering the clusters, it may be noted that cluster 1 and 2 are very much teacher-centred; cluster 3 is learner- centred; and cluster 4 also appears to be learner-centred but with much of the burden of learning placed on the student.

For Grasha (1996:205), there are numerous factors which determine the appropriate cluster for a classroom environment. They are the teacher's response to students' learning styles, the students' capability to handling the material in the course, their need for the teacher to directly control classroom tasks and their willingness to build and maintain relationships with their students. Thus, it is not as easy as simply choosing among elements in each of the four clusters.

2.3.3 Concluding remarks on teaching styles.

While reviewing literature related to teaching styles, the researcher has been able to make several conclusions.

Firstly, there appears to be similarities in the differentiation of styles across a number of models, for example, both Grasha and Benzie describe one teaching style as that of a facilitator. Benzie and Pratt consider teaching styles across a spectrum ranging from teacher-centred to learner-centred approaches.

Secondly, thinking about learning styles is useful in that it encourages teachers to think of different ways to make learning meaningful for the student. This involves the teacher being involved in some form of internal dialogue reflecting on what works and what appears to be the best strategy for a particular group of students.

Thirdly, in consideration of teaching and learning styles, it is evident that strategies will have to be continuously revised in that the basic content may be the same but the student groupings will differ and delivery will have to cater to these differences.

Fourthly, while there may be diverse learning styles within one classroom, it would seem that the inclusion of a few different teaching methodologies should be sufficient

to cater to the needs of the majority of the learners. The key is to find the correct combination of styles.

Finally, each teacher is unique and has plenty to bring into an educational setting. Therefore, it is within his/her power to utilise his/her individuality to be as effective as he/she possibly can in the learning environment.

2.4. "To match or not to match?" Research findings describing the ongoing debate.

In this section of the literature study, the researcher briefly outlines the findings of other research carried out regarding the topic of matching teaching and learning styles.

It appears that this is a rather controversial topic in research circles as there are research findings which support the idea of matching, and those that do not. Coffield *et al* (2004: 40) quotes the findings of two other researchers who found that for every nine studies that showed that learning was more effective where there is a match, there is nine to show that learning is effective when in fact there is a mismatch. Both viewpoints will be further examined.

2.4.1 Research findings in favour of matching teaching styles to learning styles

Larkin-Hein (2000:12) contends that the adoption of a learning style approach in the classroom improves student interest and motivation to learn, primarily because it allows for alternative teaching strategies designed to accommodate a diverse population of learners. This viewpoint derives from studies carried out with non-science majors enrolled for an introductory physics course at an American university. The Dunn and Dunn model was used as a basis for the study with all students given the PEPS instrument at the beginning of the course.

In her book, "How to implement and Supervise a Learning Style Program", Dunn (1996) describes case studies as evidence supporting a learning style school programme. One case study is of an eleventh grade English teacher who implemented a learning styles approach in her regular 11^{th} grade class and taught the identical curriculum to an accelerated 11^{th} grade class in a traditional way. Her regular students

outscored the accelerated students. Another case study indicates significantly higher Standardised Achievement Test (SAT) scores of learning disabled and emotionally handicapped students in learning style schools. SAT scores in several United States schools were significantly improved when children were moved from traditional classrooms to learning style classrooms at elementary schools.

Within the domains of physics and also engineering, it appears as if more educators are noting the importance of teaching with learning styles in mind. In a study of college science instruction, Sheila Tobias investigated why many students were dropping out of science courses after the first year introductory courses (Felder, 1993:286). The article cites a number of negative features in the course including lack of motivating interest; relegating students to almost complete passivity; and a focus on algorithmic problem solving rather than conceptual understanding. These points, raised by Tobias, can be expressed directly as a failure to address certain common learning styles. Research quoted in the article supports the perspective of matching in that it found that students whose learning styles were compatible with teacher instruction in a course retained information longer, could apply it more effectively, and ultimately had a more positive disposition towards the course than those students where mismatching was evident.
The article contains a warning that if mismatches are severe, students are more prone to losing interest in science and becoming one of more than 200,000 who switch to other fields after the first year of college science instruction (Felder, 1993:289).

The Index of Learning Styles (ILS) is an instrument used to define learning preferences on the Felder-Silverman learning styles model. This instrument is taken by many to assess learning style preferences. It has also come under fire from critics that it lacks validity and reliability. In an attempt to authenticate its reliability and validity, Felder and Spurlin (2005: 103) conducted several research studies, one if which tested the test-retest reliability of the ILS. When testing this aspect, the interval between test administrations must be large enough so that test subjects do not remember their responses from one test to the next. The results conclude that the test-retest reliability of the ILS is satisfactory, even after an interval of eight months and a sample size of only twenty four (Felder & Spurlin, 2005: 107).

Construct validity is also investigated in Felder's study. In essence this tests the extent to which an instrument actually measures what it claims to test. Instrument scores are said to have convergent construct validity if they correlate with quantities with which they should correlate (Felder & Spurlin, 2005:108). In the studies described, it is apparent that there are similarities in the profiles of engineering students at different institutions, as well as similarities between students at the same institution in different years. These results support the claim of convergent validity for the first three scales of the ILS.

Basically, Felder's article reflects that as long as the ILS is used to enhance instruction in an attempt to help students understand their strengths and note their areas of improvement, then the current version of the index may be considered reliable, valid and suitable (Felder & Spurlin, 2005: 111).

Support for matching teaching styles to learning styles appear to come from a number of studies that involve computer-based or multi-media based instruction.

In a study on using multimedia to address diverse learning styles, Montgomery (1995) demonstrated that using multi media is effective in addressing learning styles that are typically neglected by traditional teaching methods. The research suggests that computer and multi-media software can really fill in the gaps caused by a dichotomy of learning and teaching styles. Furthermore, awareness of the pedagogic needs of various learning preferences can be used to enhance the effectiveness of multimedia software.

A study by Ford and Chen (2001) explores the relationship between matching and mismatching instructional presentational style to students' cognitive style in a computer based learning environment. It involved seventy three post-graduate students creating web pages using HTML where one group received instructional material that matched their cognitive styles and the other group was mismatched. Results showed that performance in matched conditions were significantly higher than in mismatched conditions.

However, more interestingly, significant differences were found for gender. Results showed that matching mainly affected male students. Overall, this paper provides

support for the notion that matching instructional or teaching styles to learning styles can have significant effects on student achievement.

Garland and Martin (2005) investigated whether gender and learning styles play a role in how an online course should be designed. In their study, the Kolb learning style inventory was used to determine learning style preferences of 168 students. Some of the students were exposed to traditional face-to-face courses, and others were exposed to courses taught online that were matched to their learning preference. The population was also divided by gender to see whether this was also a factor.
The results of this study highlight a number of points (Garland & Martin, 2005: 77). Firstly, it supports previous research that learning style characteristics of online learners are different to those of learners in traditional courses. Secondly, it suggests that students with any learning style can learn successfully online. Nevertheless, through teacher and student co-operation in identifying the student's learning style, both can learn what materials should be developed that would more effectively engage students and enhance learning. Thirdly, the results show that gender is a factor in the relationship between learning style and student engagement. These results have significant implications for the designers of online courses.

Another area of support for matching teaching and learning styles appear to be in teaching English as a second language (ESL) classes. According to Felder and Henriques (1995: 21), mismatches often occur in teaching foreign language students English and this has drastic effects on the quality of their learning and their consequent attitude toward the subject. This is simply due to the fact that there are several dimensions of learning styles relevant to foreign and second language education that is often ignored, one possibly being culture.

In a similar study, Zhenhui (2001) illustrates how the traditional learning styles patterns of East Asian students are probably influenced by their culture and they thus experience problems when exposed to a teacher whose teaching style is completely at odds with how they have traditionally been learning. He provides an example of a committed American teacher who could not understand her students' negative responses to her kinaesthetic, global style of teaching until she realized that they were

inherently introverted, analytical and reflective learners. Many other examples of similar mismatching are expounded in the paper.

Research on learning styles has found that there is variation in the learning styles of different cultural groups. However, Hillberg and Tharp (2002:1) shows that great variation can be found even within a cultural group. Their studies focused on American Indian and Alaskan Native students. The article refers to several research endeavours in support of matching teaching to learning styles.

In 2000, Hillberg, Tharp and DeGeest (quoted in Hillberg & Tharp, 2002:3), studied Native American Middle school students in a two week unit on fractions, decimals and percentages, and found that students in the experimental group, where efforts were made at diversity of methodology, retained more of what was taught and had more positive attitudes towards mathematics.
In another quasi-experiment involving 6th grade math classes on an Indian reservation in New Mexico, Hillberg, *et al* carried out an eight week study (Hillberg & Tharp, 2002:3). Students in an experimental group were placed in self selected small groups and rotated through various learning stations engaging in different tasks. The activities emphasised visual, tactile and auditory material in addition to allowing some self directed learning. The results showed that the learners in the experimental group outperformed their peers in the control group with respect to their achievement in mathematical concepts and skills.

Minotti (2005: 67 – 89) examined the effects of using individualised, learning style based homework prescriptions on the achievement and attitudes of sixth, seventh and eighth grade students in an urban, parochial school in New York. The population was divided into two groups with one group receiving learning style based homework prescriptions and the other group receiving guidelines for traditional study strategies. Results showed that both groups demonstrated increased levels of achievement in reading, math, social studies and science. They also demonstrated higher attitude test scores after treatment. However, the students in the experimental group with individualised learning style based homework clearly showed much higher gains in their achievement.

According to Hayes and Allinson (quoted in Hillberg & Tharp 2002: 3), ten of seventeen studies they examined support the hypothesis that instructional strategies influence the achievement of students with different learning styles.
Hillberg and Tharp (2002:4) conclude that learning styles research would benefit from the development of a better, more unified theory. They further conclude from work by other researchers that much of the research on learning styles to date has been exploratory and that what is needed is more investigation into the aspects, nature, role and applications of learning styles.

2.4.2 Research findings opposing matching teaching styles to learning styles

As there are many research findings to support the benefits of matching teaching styles to learning styles, there are also those studies that are opposed to matching as an answer to poor performance. In this aspect of the literature review, these findings will be described.

One of the key criticisms levelled at learning styles proponents is the lack of reliability and validity of the instruments used to determine learner preferences. Ellis (2001:155) states that perhaps this can be traced to the ambiguities of the meanings of learning style. He uses the fact that a factor analysis of four learning styles instruments showed that each instrument was measuring distinctly different characteristics. This affects the construct validity of the instrument.
On a similar note, Becta (2005: 2) raises concerns about the lack of longitudinal studies that is necessary to ascertain how stable learning styles are. Even if the learning styles are stable, many of the instruments cannot be relied upon to give consistent results from one test to the next, further putting into question its reliability.

Several other criticisms described by Ellis (2001:156) include these points:

- Many learning style theorists have not distinguished learning styles constructs from intelligence.
- The experimental designs employed in classroom based learning styles research appear to be weak and do not have adequate controls.

- Some of the results of learning styles research could be generated because of the Hawthorne effect. This refers to enthusiasm and support that is created by doing something new.
- There could be some element of bias on the part of the researchers as each one stands to gain financially from propagating their own theory and accompanying instrument to measure learning preferences.
- The Dunn and Dunn model is questioned on the basis that much of the research alluded to as their research base come from studies published in journals that have little or no reputation for publishing carefully refereed, empirical studies. Many of the evidences used were also from unpublished doctoral studies.
- There have been no published accounts of any large scale programme evaluation conducted to determine whether an in-service programme on learning styles has contributed much to student achievements.

Another critical point is that research in the field of learning styles appear to be conflicting and is often methodologically flawed (Becta, 2005:2). While it draws from pedagogy, psychology and neuroscience, it does not fully engage any one of these fields. Furthermore, there are too many theories with each one emphasising a different aspect, for example, some emphasise sensory pathways and how information is received while others espouse multiple intelligences. Thus there is some confusion in terms of concepts, models and inventories. Due to all of this, there is no one universally accepted model of learning styles.

In a May 2005 Guardian newspaper article, Revell writes about a literature study headed by Professor Frank Coffield of the London's Institute of Education. In the study thirteen of the most influential learning styles models were examined according to the following named criteria:

- Theoretical origins.
- Definitions of terms.
- The style questionnaire.
- The claims made by the authors.
- External studies of these claims.

- Independent empirical evidence of the impact on teaching and learning.

They found that none of the most popular learning styles theories had been adequately validated through independent research. To quote from the article: “The idea of a learning cycle, the consistency of visual, auditory and kinaesthetic preferences, and the value of matching teaching and learning styles were all ‘highly questionable’.”

Another argument forwarded against implementation of a learning styles approach is that any large scale adoption of matching is simply unrealistic especially given the demands for flexibility it would make on teachers and trainers (Coffield, *et al* 2004:41).
Simply stated, it is hard to imagine teachers changing their teaching style to accommodate up to thirty different learning styles in one classroom. This sentiment is echoed by Doyle and Rutherford (2003:20), who believe that teachers will be faced with formidable problems because of the sheer diversity of work teaching to learning styles entails. First the teacher must determine which dimension of learner style to consider important. This is difficult especially if a classroom teacher is not adequately prepared to use any of the instruments. Second is the need to consider the amount of diversity to accommodate. A crucial question is: where does the teacher stops in the pursuit of diversity? Finally, there is the problem of devising instructional materials to accommodate the variations of learning styles, all of which require a high level of skill in managing multiple formats within a complex classroom setting.

According to Doyle and Rutherford (2003:22), of twenty two studies on the effects of matching reviewed, only two showed significant effects on achievement. Other research mentioned in their survey include evidence to suggest that while cognitive similarities between students and teachers did affect classroom interactions, it did not seem to influence achievement. Their brief survey therefore does not support unbridled enthusiasm for programmes designed to match learning and teaching styles.

In an experimental design into the effect of student learning characteristics and teaching approaches, Ching-Sue (2005) explored the potential to promote students’ understanding of difficult science concepts by examining the inter-relationships among the teacher’s instructional approach, students’ learning preference styles, and

their levels of the learning process. The results of her study showed that matching students' learning style with teaching preferences did not result in any significant change in students' retention or understanding of concepts like air pressure.

2.5 Conclusion

From this literature review, it is evident that the issue of matching teaching styles and learning styles is still a controversial topic in need of more thorough research. Nevertheless, there are important implications for the teacher thinking about implementing a learning styles approach. An effective teacher needs to have a resource bank of different teaching methods and activities to draw on from time to time so that maximum learning for as many students as possible can be facilitated. Teachers also need to be aware of the pitfalls of subscribing too much to the notion of learners having one dominant style that is fixed. As stated by McKeachie (1996:1), the most serious undesirable side effect from the use of learning style concepts is that styles are often considered to be fixed by the teacher, and in this way it can then limit the students' ability to learn in ways that do not fit their style. Learning goes awry when teachers become so committed to a particular set of learning style categories that they miss individual differences and changes over time. Sometimes it may also be worthwhile to attempt to expand a learners thinking by deliberately setting work outside of his preferred style.

The research findings uncovered during the literature review was essential in informing the direction and course of the investigation. In chapter three, the selected research design and methodology for the study is described.

Chapter Three: Research design, methodology and data analysis

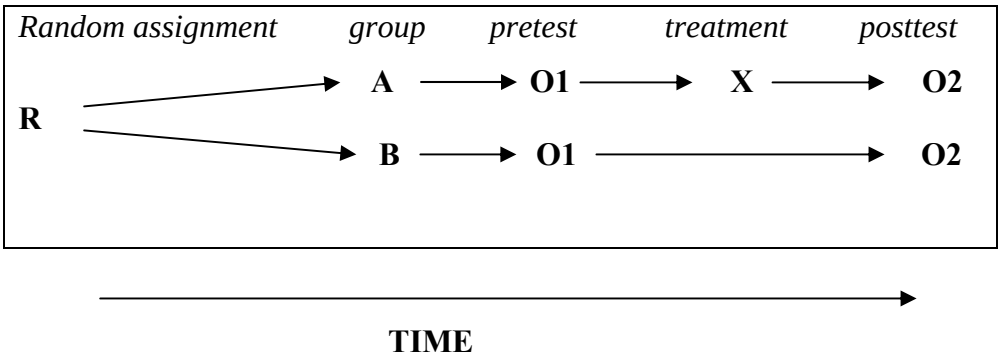
3.1 Experimental research design

A quantitative approach, specifically an experimental research design, was selected for this study. Such a design has six distinguishing characteristics, namely, statistical equivalence of subjects in different groups; comparison of two or more groups or sets of conditions; direct manipulation of at least one independent variable; measurement of each dependent variable; use of inferential statistics; and potential for maximum control of extraneous variables. The experimental research design of choice is that of a pre-test posttest control group design (McMillan & Schumacher, 2001:321).

3.1.1 Pretest – posttest control group design

The following illustration, figure 3.1, adapted from McMillan and Schumacher (2001:335), exemplifies the pretest posttest control group design.

Figure 3.1: Pretest – posttest control group design



The letter R represents the random selection of the sample from the population. . In this case, the population comprises of all the students in grade six at the school the researcher is currently teaching at, arranged in five class units.

The sample selected comprised of two groups, represented by A and B. Group A is referred to as the experimental group and group B constitutes the control group. A pretest (O1) is administered to both groups. The experimental group then receives the treatment (X) while the control group receives instruction in the usual traditional manner of teaching, without any knowledge of their learning style preferences. The pretest and posttest are two different tests. However, both the control group and the

experimental group will be administered with the same pretest (O1) and the same posttest (O2).

The pretest (O1) and posttest (O2) results are compared for any degree of statistical significant difference for each group respectively.

The independent variable manipulated for the study (X) is the teaching style employed to deliver two units of enquiry for a grade six science class. For the experimental group, the teaching style of the teacher is cognisant of the learning preferences of the students. The control group is taught in ignorance of their learning style preferences. The dependent variable is the test scores achieved on the two units of enquiry.

3.1.2 Threats to internal validity

The pretest- posttest control group design controls four sources of threats to the internal validity of a study (McMillan & Schumacher, 2001: 337).

Within this study, the threat of **selection** is controlled to some extent. Although subjects will not be assigned in a strictly random way, the groupings of learners are such that that there is an equitable distribution of learners at different levels of intelligence, with different strengths, in each class grouping.

Events that are external to the study affect both groups equally and in this way, the threat of **history** is controlled. However, this does not include special circumstances unique to any individual within a group that may influence the results.

In order to control any threat as a result of **diffusion of treatment**, the two groups will be taught separately from each other. The researcher will instruct the experimental group on the two units of enquiry and another teacher will teach the control group. The same units will be taught but in isolation of each other. In this way, conditions intended for one group is not transmitted to the other group.

Instrumentation is controlled in that both groups are administered with the same standardised unit tests.

3.2 Research problem and null hypothesis

The research problem for the study is indicated by the following question:
"Is there a relationship between matching teaching and learning styles and the academic success in Science?"

The null hypothesis for the study is stated below:

Null hypothesis: *there is no significant difference between the pre- and posttest means for the experimental and control groups respectively.*

The inferential statistical test selected to test the null hypothesis is the dependent samples t-test since the average/mean scores of the same group in two different tests are compared.

3.3 Research Methodology

3.3.1 Sampling

A sample is a small subset of the population that has been chosen to be studied (Lunsford & Lunsford, 1995:105).
The population, from which the sample was selected, comprised of 87 grade six students between the ages of 11 – 13years, in a Middle East school setting. The sample was selected from the school at which the researcher is employed as a science teacher. The 87 students were arranged in five class units, with each class having approximately seventeen students.
Two class units, each comprising sixteen students, were randomly selected as the experimental group and the control group respectively. This was in order to assume and maintain statistical equivalence.

The sampling method for **selecting the population** for the study was a non-probability sampling of convenience. A convenience sample refers to a group of subjects selected on the basis of being accessible or expedient (McMillan &

Schumacher, 2001:175). Thus, it is not random. Rather, it is based on the availability of subjects and the added advantage of convenience that it offers.
However, the sample, comprising of two class units, was **randomly selected**.
The classes selected were representative of the entire sixth grade population in terms of age, cultural background, educational experiences, and socio- economic status.
The experimental group was comprised of eight girls and eight boys to sustain gender equivalence. The gender composition of the control group was seven girls and nine boys.

3.3.2 Data collection

3.3.2.1 Determining learning style preferences

The empirical aspect of the research was carried over a time period of nine weeks. Prior to the actual treatment being administered, the experimental group responded to a learning styles inventory in order to determine the learning preferences within the class unit.

(a) Choice of learning styles inventory

The inventory used was developed by Connor (2005). It essentially deals with how information is processed. This inventory was chosen because it had fewer items and therefore did not take too long for the students to complete. It was relatively easy to interpret.

The inventory also provided feedback in terms of whether the student is primarily a visual, auditory, or tactile/kinaesthetic learner. In the inventory, students are informed of their primary and secondary learning style. A short list of guidelines is also provided to help the student understand how he/she learns.

Another reason for selecting this inventory was that it facilitated the task of planning lessons in accordance to learning style preferences. With students broadly grouped into three categories, the teacher's task of teaching to learning styles becomes more attainable, or is within more realistic boundaries. A copy of this inventory is included as **appendix A.**

(b) Administering the inventory

Prior to administering the learning styles inventory to the 16 subjects in the experimental group, the teacher explained the procedure to follow in answering the items on the inventory. Guidance was provided in terms of explaining some of the terminology present in the inventory.

This was necessary as the majority of the learners in the study were of a Middle Eastern background for whom English is a second language. Nevertheless, the inventory was successfully completed.

After completing the inventory, students identified their primary and secondary learning preferences.

The following table illustrates the grouping of the students in the experimental group in accordance with their learning styles:

Table 3.1: Learning styles of experimental group

Number	Primary learning style	Secondary learning style
1	Tactile/Kinaesthetic	Auditory
2	Visual	Auditory
3	Visual	Tactile/Kinaesthetic
4	Visual	Tactile/Kinaesthetic
5	Visual	Tactile/Kinaesthetic
6	Visual	Auditory
7	Visual	Auditory & Tactile/Kinaesthetic
8	Auditory	Visual
9	Visual	Auditory
10	Did not have a primary style, but scored equal in all three categories (4)	
11	Tactile/Kinaesthetic	Visual and Auditory
12	Visual	Tactile/Kinaesthetic
13	Did not have a primary style, but scored equal in all three categories (4)	
14	Tactile/Kinaesthetic	Visual
15	Visual	Tactile/Kinaesthetic
16	Visual	Tactile/Kinaesthetic

(c) Analyzing the results of the inventory

A frequency distribution was used to analyze the results of the learning styles inventory. This analysis provided key information as to the preferences of the learners within the experimental group.

The frequency distributions of primary and secondary learning preferences were used as a starting point from which the science units of enquiry were designed.
The following two tables indicate the frequency distributions for the learning style preferences:

Table 3.2: Frequency distribution (%) for primary learning style

Primary Learning style	Total (16)	%
Visual	10	62.5
Auditory	1	6.25
Kinaesthetic	3	18.75
No preference	2	12.5

According to the inventory, 62.5% of the students are primarily visual learners, 18.75% are primarily kinaesthetic/tactile learners. Only a small percentage of learners (6.25%) are primarily auditory, while 12.5% of learners did not show any preference.

Table 3.3: Frequency distribution for secondary learning style

Secondary Learning style	Total (16)	%
Visual	2	12.5
Auditory	4	25
Kinaesthetic	6	37.5
No preference	2	12.5
Visual and auditory	1	6.25
Auditory & tactile/kinaesthetic	1	6.25

A kinaesthetic/tactile learning preference was the second choice for 37.5 % of the learners, with 25% choosing an auditory style; 12.5% a visual style; 12.5% indicated no preference; while 6.25% indicated a combination of styles namely, visual and auditory; or auditory and tactile/kinaesthetic.

3.3.2.2 Treatment

The treatment inherent in the study included the formulation of two scientific units of enquiry, namely:

- Acids and Alkalis
- Electricity.

The two unit plans are included as **appendices B and C** respectively.

In compiling the unit plans for the two units of enquiry, the researcher took into consideration the learning preferences as indicated by the frequency distribution. This implies that care was taken to make lesson plans as visually stimulating and hands- on as possible, since the majority of learners preferred a visual or kinaesthetic style.

(a) Catering to the visual learner

Willoughby (2005:1) states that audio-visual presentations, on site field trips and demonstrations are key methods that can be employed in science teaching to appeal to the visual learner. Within the unit on Acids and Alkalis, the effect of indicators on acids and alkalis was demonstrated using a specific indicator. Students were also allowed to investigate the effect of different indicators on household substances to determine whether they were acidic or alkaline in nature. Educational video and DVD resources were used to complement concepts covered in lessons.

Within the unit of electricity, students viewed a video on the history of the development of our present understanding of electricity. This encouraged discussion and comparison of how our present electrical appliances and devices have evolved over the years. Links were made to the environmental impacts of high energy consumption for the generation of electricity.
The teacher also demonstrated the connections and working of simple series and parallel circuits.

One of the key techniques used to enhance understanding and retention of knowledge when presenting lectures was imagery. As stated by Silverman (1998:1) *"A picture is worth a thousand words."*

Within discussion or lecture type lessons, the whiteboard and overhead projector was used to draw diagrams or flow charts to illustrate the concept being discussed. Silverman (1998) also encourages the use of the discovery (inductive) technique of learning as this capitalizes on the pattern finding strength of visual learners.

(b) Catering to the tactile/kinaesthetic leaner

Tactile/kinaesthetic learners are essentially 'hands on' type of learners as they learn by doing. They prefer to do experiments themselves rather than watch a demonstration.
Within the unit of acids and alkalis, opportunity was provided for hands on activities through different experiments, for example, students made their own indicators and compared them with indicators made by other students in the class in order to determine which natural indicator was the most effective. (A handout for this lesson appears as **appendix D** in chapter four). Students discovered the properties of bases through employing their sense of touch.

Within the unit of electricity, students had ample opportunity to manipulate circuits, create circuits and investigate practically the workings of rheostats. They examined and used measuring instruments like ammeters and voltmeters.

(c) Catering for the auditory learner

Although only a small percentage of learners were primarily auditory, a vast amount of information is passed from teacher to student through this mode. Therefore, any instruction cannot be planned without effort being made to enhance this aspect of learning.

Auditory learners can often follow directions very precisely after being told only once or twice what to do. Some auditory learners concentrate better when they have music or white noise in the background, or retain new information better when they talk it out (Smith, 2006). To cater for auditory learners, care was taken to provide clear and

simple instructions during each lesson. For experiments, a simple step by step procedure with guiding diagrams was used. Assessments were also varied in that instead of having students write some reflections, they were allowed to present it orally.

During revision before tests, auditory learners were encouraged to use acronyms, song, talking aloud or even rapping to help them remember the concepts.

(d) Other factors to enhance learning

Willoughby (2005:1-2) outlines several other strategies which are useful for implementing differentiated learning experiences, many of which were incorporated into the planning and delivery of the science lessons. They include:

- Using small group instruction on a regular basis.
- Using learning stations, especially with different science experiments at each station for students to progress through.
- Using differentiated assessment tools, for example, experimental reports, power point presentations, creating stories, model building (electricity games)
- Using the computer for animation videos or simulation activities.
- Relating science topics covered to real life issues, for example the problem of acid rain; and the impact of fossil fuel burning for electricity generation on the environment.

3.3.2.3 Data Collection Instrument/Test

For the purposes of this study, the second trimester Science grades of the experimental and control groups were used as a pre-test score (O1).

At the end of the first unit of Science, a post-test (O2) was given to both groups and the scores achieved by each student were recorded. The post-test took the form of a Science unit of enquiry written test.

The treatment (X) was repeated in the experimental group for the second Science unit and another written test was used to gain more data. Both groups wrote the test and the test scores were once again recorded. For both groups, the averages or means were calculated. The means of both tests were combined to represent the measure of achievement for the third school term. Both tests scores were used to enhance consistency and relevance of results.

The pre-test and posttest means of both groups were then compared for any statistically significant difference by implementing the dependent samples t-test.

A table showing the pretest and posttest average scores is reported in chapter four.

3.3.3 Data analysis overview

3.3.3.1 The t-test

The data analysis method for the study is the *t*-test to determine level of significance. The reason for this is that means of the scores of two groups are being compared, the experimental group and the control group.
The dependant samples t-test is used to calculate the probability of rejecting the null hypothesis.

3.3.3.2 Terminology

There are several statistical terms associated with implementing the t-test to analyse data. The description of the terms presented below is adapted from McMillan and Schumacher (2001:370):

- **T-test** – a formula that generates a number which is used to determine the probability level (p-level) of rejecting the null hypothesis
- **Degrees of freedom** – mathematical concept that denotes the number of independent observations that are free to vary.

3.3.3.3 Procedure

Whenever a significance test is performed, the calculated test value is compared to some critical value for the statistics (Stat Pac Inc, 2006). The calculated t-value related to this study will be presented in chapter four.

Once the t-test score is calculated and compared, the null hypothesis is either accepted or rejected.

This depends on whether it is higher or lower than the critical value (Stat Pac Inc, 2006). A statistical value higher than the critical value indicates that the findings of the research are significant and the null hypothesis may be rejected. A statistical value lower than the critical value indicates that the findings of the research are not significant and the null hypothesis may not be rejected (McMillan & Schumacher, 2001: 371).

3.4 Pretest and posttest means

The following table represents the pretest and posttest raw scores for the experimental group and the control group. Each score is presented as a percentage. The posttest score is a combination of the scores achieved after the two units of enquiry tests were written. Thus, the table indicates the performance of the learners which is used as a measure of their achievement in Science.

Table 3.4: Pretest and posttest means

Student No.	Experimental group		Control group	
	Pretest scores (%)	Posttest scores (%)	Pretest scores (%)	Posttest scores (%)
1.	**58**	**69**	**69**	**75**
2.	**69**	**58**	**69**	**81**
3.	**77**	**81**	**61**	**61**
4.	**61**	**69**	**69**	**67**
5.	**52**	**56**	**69**	**64**
6.	**61**	**69**	**53**	**61**
7.	**58**	**72**	**50**	**61**
8.	**83**	**97**	**56**	**64**
9.	**63**	**75**	**56**	**69**
10.	**63**	**72**	**86**	**92**
11.	**66**	**77**	**56**	**61**
12.	**66**	**83**	**75**	**67**
13.	**63**	**69**	**83**	**75**
14.	**75**	**77**	**55**	**58**
15.	**69**	**81**	**61**	**64**
16.	**58**	**69**	**42**	**36**
MEANS	**65.18**	**73.37**	**63.12**	**66.00**

The raw data for the pretest and posttest scores was used to calculate the average or mean scores. The mean scores for both the experimental group and the control group are reflected in table 3.4 above.

3.5 Dependent samples t-test

3.5.1 Discussion of t-test calculation

In a t-test for dependent samples, the test formula must take into account the inter-relationship between the groups being compared, namely, the experimental group, and the control group (McMillan & Schumacher, 2001:620).

The following formula taken from McMillan and Schumacher (2001:620) was used to calculate the test value:

$$t = \frac{\bar{D}}{\sqrt{\frac{\Sigma D^2 - \frac{(\Sigma D)^2}{N}}{N(N-1)}}}$$

In the formula:

$\bar{D}$ represents the mean difference for all pairs of scores

ΣD^2 represents the sum of the squares of the differences

$(\Sigma D)^2$ represents the square of the sum of the differences

N represents the number of pairs of scores

$N - 1$ represents the degrees of freedom (which is one less than the number of pairs of scores)

3.5.2 Data analysis

The results of the data analysis are presented in table 3.5 below. The table compares the sample size (n); the pretest –posttest means; the calculated t-value; the degrees of freedom; and the probability level of the experimental group and the control group.

Table 3.5: presentation of analyzed data

	Experimental group	Control group
Sample size(n)	**16**	**16**
Pretest means	**65.18**	**63.12**
Posttest means	**73.37**	**66.00**
Calculated t-value	**5.2**	**1.6**
Degrees of freedom (df)	**15**	**15**
Probability level (p)	**$p < 0.01$**	**$p > 0.05$**

3.6 Interpretation of data

3.6.1 t-test values

The level of significance is used to indicate the chances of being wrong in rejecting the null hypothesis (McMillan & Schumacher, 2001:364). It is also referred to as the level of probability (p level), and is expressed as a decimal that indicates how many times out of a hundred or thousand one would be wrong in rejecting the null, assuming the null is true.

In other words, it tells one the chance probability of finding differences between the means. According to McMillan & Schumacher (2001:365), the lower the level of significance, the more confident one is that it is safe to reject the null hypothesis.

In this study, the calculated t value for the experimental group is 5.2 while the critical value at the 0.01 level is 2.94. *(Critical values are taken from the t-distribution table on page 371 of McMillan & Schumacher).*

The critical value is less than the calculated value at this level. This implies that the observed difference in means is greater than could have been expected under the null hypothesis. Therefore, the null hypothesis can be rejected at the 0.01 level. This difference indicates that there is a 99% confidence of rejecting the null hypothesis.

Rejection of the null hypothesis implies that there is a significant difference in the pretest and posttest mean scores of the experimental group.

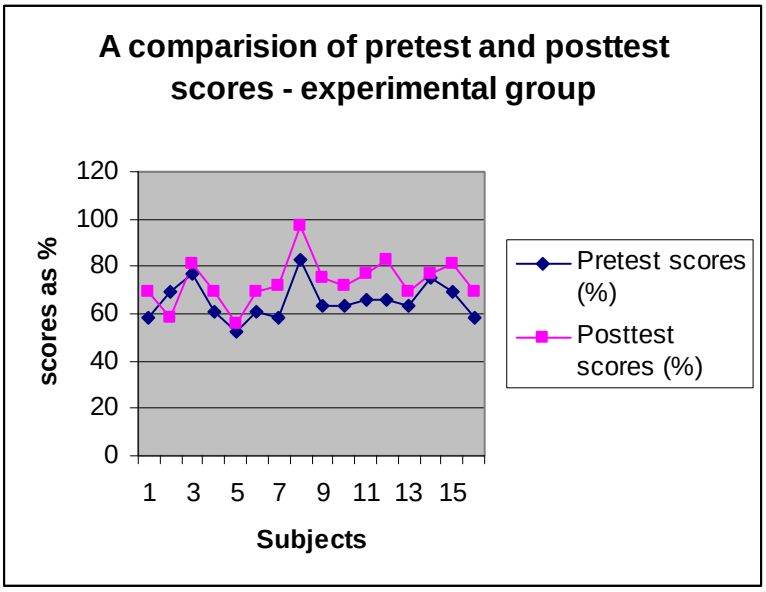
Thus, the conclusion may be made that there is a significant difference in science achievement of 6th grade learners when teaching styles are matched to learning styles.

The calculated t –test statistic for the control group is 1.6. The critical t value, at the 0.05 level from the t-distribution table, is greater than the calculated value. Therefore, the null hypothesis is accepted.

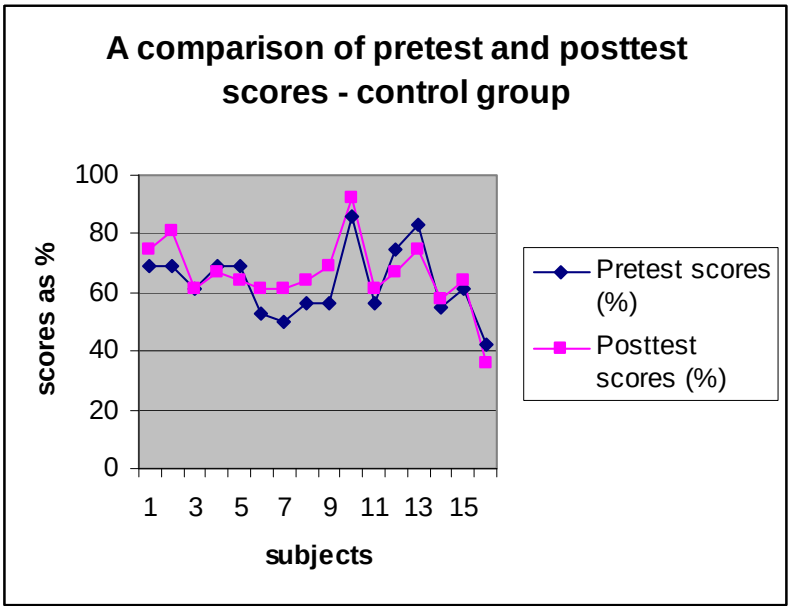
This implies that there is no significant difference between the means of the pretest and posttest scores of the control group with respect to achievement in science.

3.6.2 Pretest and posttest means – a graphical presentation

The following graphs represent the difference in the individual pretest and posttest scores for each subject in the sample in the experimental group.

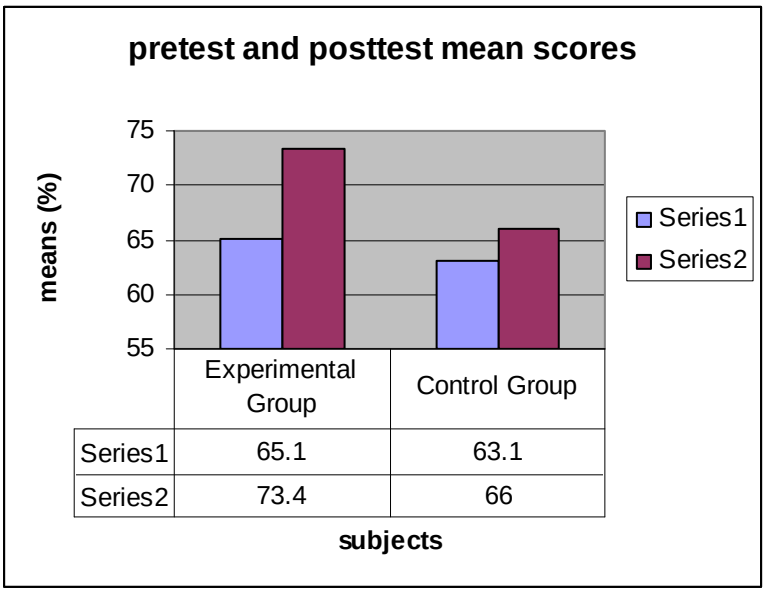


The following graphs represent the difference in the individual pretest and posttest scores for each subject in the sample in the control group.



As is evident in the graphs, the posttest scores for the experimental group appear to show greater variation or increase from the pretest scores.

In the bar chart below, series 1 represents the pretest scores and series 2 represent the posttest scores.



A comparison of the pretest and posttest means indicate an increase of 8.3% for the experimental group while for the control group, the increase is a minimal 2.9%. Again, the data indicates a greater variation in pretest posttest scores for the experimental group than for the control group.

The conclusions, recommendations, and implications of the data analysis for this study will be discussed in chapter four.

CHAPTER FOUR: Summary, conclusions, implications and recommendations

4.1 Summary

The aim of undertaking this specific research topic was to investigate the impact of matching teaching instruction to learning styles of students, with specific reference to their achievement in Science. The researcher intended to investigate whether matching teaching styles of the teacher to learning styles of 6th grade students significantly improved their test grades for two Science units of enquiry.

A pretest – posttest control group design was selected as an appropriate research design. The population for sampling comprised of the sixth grade learners at the educational institution the researcher was teaching at. A convenience method of sampling was deemed most appropriate for selecting the population for the study. The class units chosen for the experimental group and the control group were randomly selected from the population.

Both groups were pretested on the same test. The experimental group was then instructed in two units of Science, namely: Acids and Alkalis; and Electricity, in accordance to the learning preferences. The control group was taught without any consideration given to their specific learning preferences. Both groups were administered with the same posttest.

In keeping with the research design, a dependent sample t-test inferential statistic method was used to analyze the data collected.

An analysis of the results showed a statistically significant difference between the pretest and posttest means of the experimental group; but not for the control group. From this, the researcher concluded that matching teaching styles to learning styles did significantly improve the achievement of sixth grade learners in Science.

4.2 Conclusion

The intended purpose of this study was to evaluate the success of teaching in accordance with learning styles, in an attempt to improve the academic performance of learners in a sixth grade science class.
The results of this study indicate that matching teaching to learning styles does indeed have a positive impact on the academic achievement of sixth grade science students. Thus, it adds to the body of evidence that exists in support of teaching to learning styles.

The higher posttest scores of the experimental group as compared to the almost insignificant increase in posttest scores of the control group illustrates the value of a learners' awareness of his own learning styles and how it can be used to maximum benefit to enhance learning.

A key motivation for this study was the question of whether students will learn better if they understood the conditions that promote their learning. This study demonstrates this in that the students were aware of how they can improve their study techniques in accordance to their preferences. It was also found that knowing and understanding conditions that promote learning serves to motivate students.

Another proposition inherent in the motivation for this study was that children can become better learners if they can broaden their preferences. Within this study, three broad sensory learning preferences were catered for, namely, visual, auditory and tactile/kinaesthetic learning styles. The results depict that by creating lessons that were varied and not strictly teacher centred had the advantage of increasing interest levels of students and this positively influenced their performance on assessments.

Therefore, it can be stated that there is a definite relationship between matching of teaching strategy to learning styles and the academic success of sixth grade learners in Science.

4.3 Limitations of the study

The researcher observed several factors that could have been possible sources of error within the study, and that could as a consequence, place limitations of the reliability and generalizability of the study.

These include:

- The time frame – the data collection phase of the research was conducted over a period of eight weeks. It is the opinion of the researcher that the reliability of the research findings would be enhanced by a longer period of carrying out the actual treatment of the study.
- Possible language barriers – although the school in which the research was conducted is an English medium school, the majority of the learners are Middle Eastern for whom English is a second language. Therefore, it is possible that this could have influenced the responses on the questionnaire, even though care was taken to explain concepts inherent in the inventory.
- Diffusion of treatment – this is a possibility if students from the experimental group discussed their science lessons with students from the control group in the event of them meeting socially. In this way, there could have been some diffusion of treatment.
- Level of intelligence and relevant previous knowledge of the learner could also have had an effect on the results of the study.
- Size of the sample – the limited number of the population and hence the small sample size could have influenced the degree to which the findings of the research can be generalised to other populations.

4.4 Implications for teachers and parents

A study like this one holds several implications for educators and parents with regard to helping students achieve a higher level of success in school. Montgomery (1998) believes that there are many reasons to incorporate an understanding of learning styles into our teaching. These include:

- Making teaching and learning a **dialogue**, through a variety of active learning techniques that engage students.
- As student bodies become more diverse, it becomes necessary to **consider all the factors** that influence the learning of students from different races, cultures and nationalities.
- **Communicating** our message across more effectively which can only be done if presented in a multi-faceted way across the range of student learning styles.
- **Making teaching more rewarding**. Considering learning styles forces teachers to self-reflect and consider ways to change teaching methodologies and move away from being caught in teaching the way we were taught, assuming that it will work for all students.

4.5 Recommendations

4.5.1 Teachers

There are several practical modifications teachers can make to their basic lesson plans that will allow them to cater for learning preferences of their students. Following are some examples for catering to learning styles in accordance to the four modalities (Verster, 2005:1):

4.5.1.1 Visual learners

- Use wall displays posters for example colour posters of electrical circuits or the systems of the human body, flash cards, graphic organizers etc.
- DVD's, videos and computer simulation activities and games allow the learner to visualise the concept or content covered.

4.5.1.2 Auditory learners

- Use audio tapes, storytelling, songs, raps, memorisation techniques like acronyms and acrostics, as well as drill methods.
- Allow learners to work in pairs and small groups regularly as they benefit from verbal exchange of ideas.

4.5.1.3 Tactile / kinaesthetic learners

- Use physical activities, competitions, board games and role play where appropriate.
- Intersperse activities which require students to sit and listen with activities that allow them to move and be active. For example, have them observe a demonstration of an experiment and then have them carry out the same experiment on their own.
- Allow them to be active while listening to lectures or explanations, for example, have them fill in a table or while listening to a lecture or have them label a diagram while reading.

4.5.2 Parents

There is much that parents can do to facilitate their child's academic success through a learning styles approach. The key lies in educating themselves through reading relevant literature on the subject. This will promote their understanding of the factors that influence their child's learning. This point is succinctly captured in the following quotation written by a parent:

"Understanding my son's learning style has helped me understand him better and assisted me in reinforcing skills he needs to succeed in school" (Fellers, 2006:1).

What then are some of the modifications parents can make? Fellers (2006:2) offers some guidelines:

- Create a learning environment at home by ensuring that environmental factors that affect learning, like temperature and light intensity are conducive to learning.
- Encourage their children by doing activities with them, for example, buy a home chemistry kit and try out simple experiments together.
- With regard to the kinaesthetic learner, allow them to be physically active while doing homework as this helps them to focus, for example, allow them to

press a stress ball, or walk around the room while reading or trying to memorize something.

- Consider investing in book/tape selections to cater for the auditory learner.

An important recommendation for both parents and teachers is that they should always attempt to challenge the child to expand his/her learning preferences as a child with diverse learning styles is usually a more flexible learner (Fellers, 2006:1).

4.5.3 Further research

There is immense value to a pioneer study like this one in that it can inform further research in several directions, for example:

- The research itself may be duplicated in other schools and other settings, with learners of different ages, in order to evaluate the usefulness of teaching to learning styles.
- A parallel study may be carried out with bigger groups of students in order to see whether similar results are obtained.
- This study can also be adapted to other subjects, like Mathematics in an attempt to investigate the factors that influence academic success.
- Basically, the findings of this investigation can form a springboard in terms of providing preliminary data which educators can develop further through future research endeavours relating to the value of matching teaching to learning styles.
- The results of the inventory can be used as a starting point from which further research can be conducted as to how the learner can use knowledge about his/her learning style to further enhance his/her approach to learning.

4.6 Concluding remarks

It is hoped that the findings of this study can be used to enhance teaching practice and ultimately the level of success that learners can experience in school.
However, there are dangers to subscribing too strictly to a learning styles approach.

In considering a learning style method of teaching, it is important that a blind eye is not turned to the potential dangers of confining oneself to this approach only. Most notably, is the danger of assuming a child's learning style to be fixed and inherited because such a perception may limit his/her ability to learn in ways that do not fit his style (McKeachie, 1996). Teachers should therefore take care not to label children.

Furthermore, they should attempt to develop other abilities in the student so that his/her spectrum of learning preferences may be expanded. In this way, individual differences and changes over time in the student are not missed.

Another cautionary note to teachers is that matching teaching style to learning style should not be seen as a panacea that solves all classroom conflicts (Montgomery, 1998). There are several other factors such as previous history, gender, motivation, and multicultural issues that will influence the kind of learning that takes place.

It is therefore essential for teachers to be knowledgeable about all the factors that influence learning and to be mindful of the importance of both catering to and expanding the learning repertoire of their students.

APPENDIX A: Learning Styles Inventory

What's Your Learning Style?

By Marcia L. Conner

Learning style refers to the ways you prefer to approach new information. Each of us learns and processes information in our own special style, although we share some learning patterns, preferences, and approaches. Knowing your own style also can help you to realize that other people may approach the same situation in a different way from your own.

Take a few minutes to complete the following questionnaire to assess your preferred learning style. Begin by reading the words in the left-hand column. Of the three responses to the right, circle the one that best characterizes you, answering as honestly as possible with the description that applies to you right now. Count the number of circled items and write your total at the bottom of each column. The questions you prefer provide insight into how you learn.

1. When I try to concentrate...	I grow distracted by clutter or movement, and I notice things around me other people don't notice.	I get distracted by sounds, and I attempt to control the amount and type of noise around me.	I become distracted by commotion, and I tend to retreat inside myself.
2. When I visualize...	I see vivid, detailed pictures in my thoughts.	I think in voices and sounds.	I see images in my thoughts that involve movement.
3. When I talk with others...	I find it difficult to listen for very long.	I enjoy listening, or I get impatient to talk myself.	I gesture and communicate with my hands.
4. When I contact people...	I prefer face-to-face meetings.	I prefer speaking by telephone for serious conversations.	I prefer to interact while walking or participating in some activity.
5. When I see an acquaintance...	I forget names but remember faces, and I tend to replay where we met for the first time.	I know people's names and I can usually quote what we discussed.	I remember what we did together and I may almost "feel" our time together.
6. When I relax...	I watch TV, see a play, visit an exhibit, or go to a movie.	I listen to the radio, play music, read, or talk with a friend.	I play sports, make crafts, or build something with my hands.
7. When I read...	I like descriptive examples and I may pause to imagine the scene.	I enjoy the narrative most and I can almost "hear" the characters talk.	I prefer action-oriented stories, but I do not often read for pleasure.

8. When I spell...	I envision the word in my mind or imagine what the word looks like when written.	I sound out the word, sometimes aloud, and tend to recall rules about letter order.	I get a feel for the word by writing it out or pretending to type it.
9. When I do something new...	I seek out demonstrations, pictures, or diagrams.	I want verbal and written instructions, and to talk it over with someone else.	I jump right in to try it, keep trying, and try different approaches.

10. When I assemble an object...	I look at the picture first and then, maybe, read the directions.	I read the directions, or I talk aloud as I work.	I usually ignore the directions and figure it out as I go along.
11. When I interpret someone's mood...	I examine facial expressions.	I rely on listening to tone of voice.	I focus on body language.
12. When I teach other people...	I show them.	I tell them, write it out, or I ask them a series of questions.	I demonstrate how it is done and then ask them to try.
Total	Visual: _____	Auditory: _____	Tactile/Kinaesthetic: _____

The column with the highest total represents your primary processing style. The column with the second-most choices is your secondary style.

Your primary learning style: _____

Your secondary learning style: _____

Now that you know which learning style you rely on, you can boost your learning potential when working to learn more. For instance, the following suggestions can help you get more from reading a book.

If your primary learning style is visual, draw pictures in the margins, look at the graphics, and read the text that explains the graphics. Envision the topic or play a movie in your thoughts of how you'll act out the subject matter.

If your primary learning style is auditory, listen to the words you read. Try to develop an internal conversation between you and the text. Don't be embarrassed to read aloud or talk through the information.

If your primary learning style is tactile/kinaesthetic, use a pencil or highlighter pen to mark passages that are meaningful to you. Take notes, transferring the information you learn to the margins of the book, into your journal, or onto a computer. Doodle whatever comes to mind as you read. Hold the book in your hands instead of placing it on a table. Walk around as you read. Feel the words and ideas. Get busy—both mentally and physically.

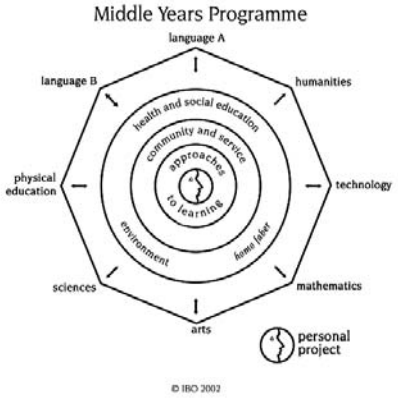
More information on each style, along with suggestions on how to maximize your learning potential, is available in the book *Learn More Now* (Hoboken, NJ; John Wiley & Sons, 2004).

A previous version of this assessment was published in *Learn More Now: 10 Simple Steps to Learning Better, Smarter, and Faster* (Hoboken, NJ; John Wiley & Sons, March 2004). Learn about the book and read an excerpt at http://www.marciaconner.com/learnmorenow/. Join the Ageless Learner mailing list to receive information about issues related to assessments and learning across the lifespan at http://www.agelesslearner.com/joinus.html.

MLC120205

APPENDIX B: Unit plan – Acids and Alkalis

QATAR ACADEMY
Middle Years Programme
Unit Planner



MYP Subject Group	SCIENCES	**Subject**	SCIENCE	**Grade**	6
Unit Title	ACIDS AND ALKALIS		**Unit duration**	4 weeks	

Guiding Questions / Main Aims

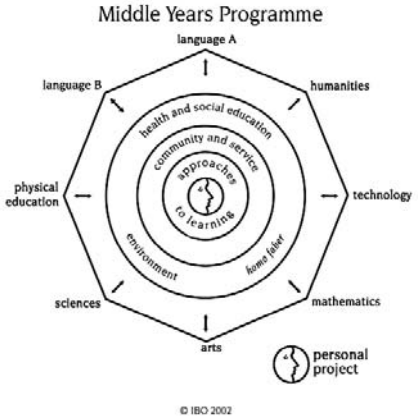
What is pH? Why is pH important in nature and how are human activities affecting this? How can we measure pH?

Core Areas of Interaction	Learning Objectives	Learning Activities
ATL (skills developed) Measurement, calibration, data collection and processing, manipulative skills, research, safety. Other AoI(s) addressed Environment (acid rain impacts on ecosystems)	• Understand that pH is a measurement relating to the chemical composition of solutions (no further details required at this level) resulting in certain distinctive properties (describe). • Know that the pH levels of natural and human-made substances vary. • Learn to make and use pH indicators safely, to accurately measure (indicate) varying pH levels of familiar and unfamiliar substances • Know that pH levels vary in the human digestive system for reasons relating to the digestion of food. • Know that some	This unit lends itself to a series of pH-testing labs. Students can extract 'juice' from a variety of strongly-pigmented plants (e.g. red cabbage) which are pH-sensitive and can thus be used to make pH indicators. The examination of pH levels in the human digestive system leads to an assessable lab investigation based on ant-acids. Suitable wildlife videos or library / web searches can illustrate the use of acid solutions by animals (e.g. ants, bees).

	animal species create acidic solutions as defence mechanisms. • Know that some forms of air pollution reduce the pH of rainwater and that the resulting "acid rain" has destructive effects (prioritise impacts on natural systems and on structural integrity of human structures)	Project work on acid rain lends itself to data-analysis activities as well as an assessed essay.
Assessment Tasks → → →		**MYP Assessment Criteria**
Essay: Acid rain – scientific methods of avoiding, reducing or treating impact		A and B
Lab report: Impact of ant-acids on the pH of prepared solution		B, D, E
Summative test		C and E

APPENDIX C: Unit plan – Electricity

QATAR ACADEMY
Middle Years Programme Unit Planner



MYP Subject Group	SCIENCES	**Subject**	SCIENCE	**Grade**	6
Unit Title	ELECTRICITY		**Unit duration**	4 weeks	

Guiding Questions / Main Aims

Describe main sources of electricity generation
Explain how electric circuits work, using the concepts of electric current, energy transfer, and voltage.
Provide students with a working knowledge of electrical safety

Core Areas of Interaction	Learning Objectives	Learning Activities
ATL (skills developed) Reading electrical meters correctly and plotting relationships Scientific Method – Investigative skills Other AoI(s) addressed Homo Faber – Electrical Inventions	• Research origins and evolution of electricity • Research and briefly discuss methods of electricity generation. Discuss contributions of prominent scientists to our modern day understanding of electricity • Investigate the basics of static electricity • Students will identify the main components of a circuit and set up simple circuits • Students will set up circuits with cells and light bulbs connected in series • Students will set up circuits with cells and light bulbs connected in parallel	• Brain pop activity – Origins and basics of electricity • Research and report on methods of electricity generation • Fathers of Electricity – Research based activity on the contributions of prominent scientists to our modern day understanding of electricity • Practical investigation – static electricity • Setting up simple, series, and parallel circuits

	• Identify symbols for circuit components and draw circuit diagrams. • Establish experimentally [basic] the functions / relationships of Ammeters and Voltmeters • Explain patterns in the measurements of current and voltage • Introduce the concept of resistance. • Investigate and establish the relationship between resistance and current • Understand the hazards related to humans using electricity	• Drawing circuit diagrams • Connecting Ammeters and Voltmeters in a circuit • Making fruit/ vegetable batteries • Internet Interactive Activity – Electrical Safety [Students receive certificates at end of activity]
Assessment Tasks **Lab Safety Activity** **Test: Scientific research, experimentation, & recording.**		**MYP Assessment Criteria** **One world, Communication, Knowledge and understanding, Scientific Enquiry, Processing Data, Attitudes in Science**
Lab report – relationship between length of resistor and amount of current in a circuit. Essay – Electrical inventions, past and present. Written unit test		Criterion B, D, E, & F Criterion A & B Criterion C

APPENDIX D: acids and alkalis practical worksheet

6a Which indicator is the best?

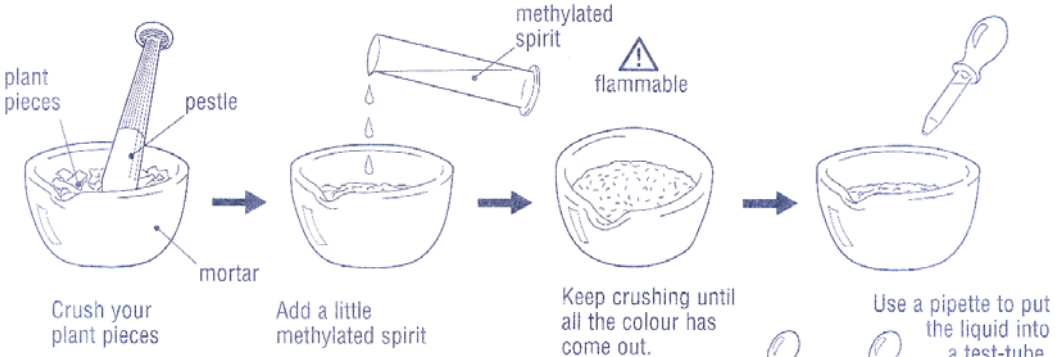
Extra Help

Name _____ Class _____

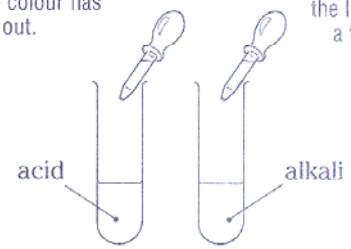
Find out which of these plants will make the best indicator.

beetroot	red currant	grass	rose petals	red cabbage	carrots

- The pictures here show you how to make an indicator from your plant material.
  Remember to make it a fair test.
  Weigh out the same amount of plant material each time.
  Add the same amount of methylated spirits each time.



- Now test your indicator.
  Add 5 drops to some acid.
  Add 5 drops to some alkali.
  Look for any colour changes.



remember to use the same amount of acid and alkali each time.

- Put your results in the table below.
  You can either write in your results or colour in the spaces to show any colour changes.

Plant	*Colour of indicator*	*Colour in acid*	*Colour in alkali*	*Good or bad indicator*
beetroot				
red currant				
grass				
rose petals				
red cabbage				
carrots				

- Which indicator is the best?

APPENDIX E: acids and alkalis homework activity

6a Interpreting results

Sc1 Skill Sheet 34

Name _____ Class _____

A class did some experiments to find which plants make the best indicator.
They ground up different fruits and flowers and tested the juices in acidic, neutral and alkaline solutions.

Here are their results:

Flower/fruit	*Colour in acidic solution*	*Colour in neutral solution*	*Colour in alkaline solution*
A	red	red	yellow
B	green	red	blue
C	light green	dark green	turquoise
D	colourless	pale yellow	orange
E	red	orange	yellow

1 Give the letter of the best indicator _____

2 Explain your choice.

_____

_____

_____

3 Choose one indicator you would not use and explain why.

_____

_____

List of tables and figures

Chapter Two

Chapter Three

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